SCIENCE AND POLICY INTEGRATION FOR COASTAL SYSTEM ASSESSMENT (SPICOSA)

Firth of Clyde Study Site

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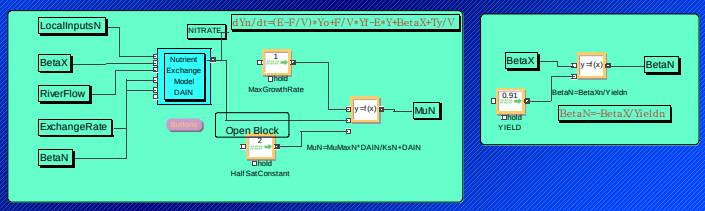
THE POLICY ISSUE

"The Implications of Increased Leisure and Tourist Use of the Firth of Clyde"

Stakeholders were keen for us to pursue the 'increased leisure and tourist use of the Clyde' as an issue due to the paucity of work being undertaken in this area.
This follows from the aim of the Scottish Government to keep pace with global tourism trends over the next decade and achieve 50% revenue growth with social, economic and environmental stability. In pursuance of this, a study of the potential for development of the sailing industry in the Clyde suggested the estuary could double its berthing capacity for recreational boating by 2015.



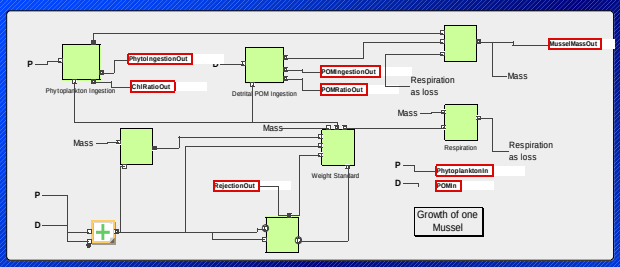
Exchange Box Model for Nitrates

This is only one of several hierarchical blocks in the model which deal with the exchange of nutrients between the loch and the boundaries (Open Sea and River). The Beta X term refers to the effect of phytoplankton reducing the total amount of nutrient through assimilation.

Systems Approach

In the case of the Scottish SSA, the application focuses on interactions between recreational yachting, phytoplankton, and mussel farming in Loch Fyne. The 'System Formulation' step requires the development of conceptual, mathematical and numerical models of the 'virtual system' centred on these interactions. A separate step proposed a framework for implementation of a simple ecosystem model. In this model the superficial waters of Loch Fyne (or any analogous system) are described as a single box in exchange with boundary conditions in the adjacent sea. The box model is being implemented by Callum Whyte (Napier) for nutrient-N, nutrient-P and phytoplankton-chlorophyll, and will be extended to include antifouling compounds released by yachts.

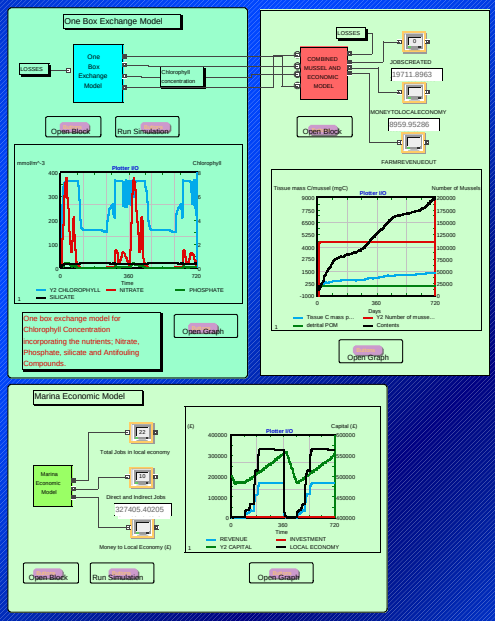
It is proposed to link this model to a model for the growth of commercially farmed mussels in Loch Fyne, at this stage treating the whole of the loch as a single unit. Because mussels are fixed in place they do not need to be made subject to physical exchange. However, it is necessary to describe their effects on the ecosystem, through removal of phytoplankton and release of nutrients, and so a mussel model can (from one perspective) be considered as part of the biological model within the ecosystem model. The mussel model is being implemented by Fiona Culhane (Napier), and the work on the present note was started by discussions of the model of Grant & Bacher (1998).



Mechanistic bioenergetic Model of Mussel Growth after Grant and Bacher (1998)

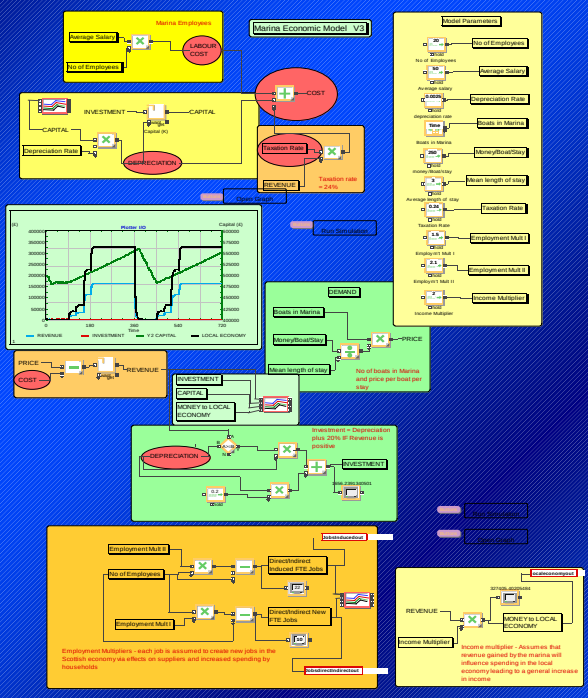
Mussel growth is dependent on two food supplies – phytoplankton and detrital particulate organic matter which are modelled as state variables. Growth is based on the assimilation of food sources with respiration as a cost. High turbidity will limit the growth as increasing proportions of the ingested food will be rejected as turbidity increases. The revenue made from mussel farming is dependent on the size of the farm and the growth of the mussels.

Combining models of such complexity obviously causes problems which will have to be resolved during the system appraisal and validation steps.
One of the biggest problems faced while constructing this model has been to integrate the Economic models with the Ecological aspects, in particular the different types of time scales used.



There are two major interacting ecological components to the model at this stage: mussels and phytoplankton.
This model predicts the growth of an individual mussel. There are two food sources for the mussel – phytoplankton and detrital particulate organic matter. This model is based on the Grant & Bacher (1998) mechanistic mussel model.
The number of mussels is estimated based on the size of the farm and given that a 200m headrope (one average mussel line) produces 25 tonnes of mussels per year. An average mussel weight is used to calculate the number of mussels (this is based on a conceptual model by Paul Tett).
Detrital matter concentration is based on an exchange box model by Paul Tett. In addition, this is modified by adding the waste produced by mussels, the settling velocity of detrital matter and the consumption of matter by mussels.
The second major ecological component of the model is phytoplankton. Phytoplankton growth is based on nutrients and water quality. The exchange model is based on the dCSTT model by Laurent *et al*. (2006) which adds a biological component to the exchange box model. In addition to assimilating nutrients in the water column thus changing their availability, phytoplankton are grazed by mussels. The changing concentration of phytoplankton will therefore have a direct effect on the scope for growth of the mussels.

Economic multipliers published by the Scottish Government in sector based input-output tables & are used to calculate the impact income made by local businesses has on the local economy in terms of money and jobs. The multipliers calculate the direct impact as well as induced and indirect impacts.



Economic Model: The marina models the revenue made as a result of the number of boats which moor and incorporates various feedback loops.

References:
Tett, P. 2008 *"From Biological to Societal Models"*, unpublished.
Laurent, et al. 2006, *" A Dynamic CSTT model for the effects of added nutrients in Loch Creran, a shallow fjord"* Journal of Marine Systems.
Grant, J., Bacher, C. 1998 *"Comparative models of mussel bioenergetics and their validation at field culture sites"* Journal of Experimental Marine Biology and Ecology, 219, pp. 21-44.